

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
13 January 2005 (13.01.2005)

PCT

(10) International Publication Number
WO 2005/002313 A3

(51) International Patent Classification⁷: A61B 5/08

(21) International Application Number:
PCT/US2004/021307

(22) International Filing Date: 1 July 2004 (01.07.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/483,961 1 July 2003 (01.07.2003) US

(71) Applicant (for all designated States except US): CAR-
DIOMAG IMAGING, INC. (CMI) [US/US]; 450 Duane
Avenue, Schenectady, NY 12304 (US).

(71) Applicants and

(72) Inventors: STERNICKEL, Karsten [DE/US]; 9 Devon-
shire Drive, Albany, NY 12205 (US). EMBRECHTS,
Mark, J. [US/US]; 15 Orchard Park Drive, Clifton Park,
NY 12065 (US). SZYMANSKI, Boleslaw, K. [US/US]; 6
Hollow Road, Newtonville, NY 12128-0301 (US).

(74) Agent: YABLON, Jay, R.; Law Office of Jay R. Yablon,
910 Northumberland Drive, Schenectady, NY 12309-2814
(US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,
ZW.

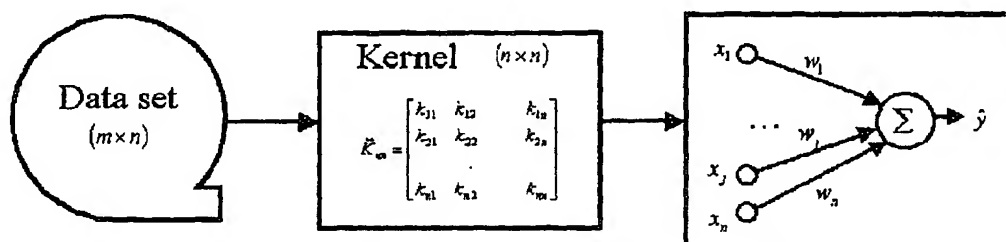
(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI,
SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted
a patent (Rule 4.17(ii)) for the following designations AE,
AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ,
CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE,
EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS,
JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA,
MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM,
PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ,
TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM,

[Continued on next page]

(54) Title: MACHINE LEARNING FOR CLASSIFICATION OF MAGNETO CARDIOGRAMS



(57) Abstract: The use of machine learning for pattern recognition in magnetocardiography (MCG) that measures magnetic fields emitted by the electrophysiological activity of the heart is disclosed herein. Direct kernel methods are used to separate abnormal MCG heart patterns from normal ones. For unsupervised learning, Direct Kernel based Self-Organizing Maps are introduced. For supervised learning Direct Kernel Partial Least Squares and (Direct) Kernel Ridge Regression are used. These results are then compared with classical Support Vector Machines and Kernel Partial Least Squares. The hyper-parameters for these methods are tuned on a validation subset of the training data before testing. Also investigated is the most effective pre-processing, using local, vertical, horizontal and two-dimensional (global) Mahalanobis scaling, wavelet transforms, and variable selection by filtering. The results, similar for all three methods, were encouraging, exceeding the quality of classification achieved by the trained experts. Thus, a device and associated method for classifying cardiography data is disclosed, comprising applying a kernel transform to sensed data acquired from sensors sensing electromagnetic heart activity, resulting in transformed data, prior to classifying the transformed data using machine learning.

BEST AVAILABLE COPY



ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations

Published:

- with international search report

- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(88) Date of publication of the international search report:
31 March 2005

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

03 AUG '05
WIPO PCT

Applicant's or agent's file reference CMIP003PCT	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/US04/21307	International filing date (day/month/year) 01 July 2004 (01.07.2004)	Priority date (day/month/year) 01 July 2003 (01.07.2003)	
International Patent Classification (IPC) or national classification and IPC IPC(7): A61B 5/08 and US Cl.: 600/508			
Applicant CARDIOMAG IMAGING, INC. (CMI)			
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <u>3</u> sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input type="checkbox"/> (sent to the applicant and to the International Bureau) a total of ___ sheets, as follows:</p> <p><input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) _____, containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p> <p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the report</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>			
Date of submission of the demand 26 January 2005 (26.01.2005)		Date of completion of this report 17 June 2005 (17.06.2005)	
Name and mailing address of the IPEA/ US Mail Stop PCT, Attn: IPEA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230		Authorized officer George Manuel <i>Diane Smith</i> Telephone No. (703) 308-0858	

Form PCT/IPEA/409 (cover sheet)(January 2004)

EPO-DG 1

21.02.2006

TEAM 14

BEST AVAILABLE COPY

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/US04/21307

Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on translations from the original language into the following language _____, which is the language of a translation furnished for the purposes of:

- ☐ international search (under Rules 12.3 and 23.1(b))
- ☐ publication of the international application (under Rule 12.4)
- ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

☒ the international application as originally filed/furnished

☒ the description:

pages 1-16 as originally filed/furnished
 pages* NONE received by this Authority on _____
 pages* NONE received by this Authority on _____

☒ the claims:

pages 17-22 as originally filed/furnished
 pages* NONE as amended (together with any statement) under Article 19
 pages* NONE received by this Authority on _____
 pages* NONE received by this Authority on _____

☒ the drawings:

pages 1-4 as originally filed/furnished
 pages* NONE received by this Authority on _____
 pages* NONE received by this Authority on _____

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☒ The amendments have resulted in the cancellation of:

- ☒ the description, pages None
- ☒ the claims, Nos. None
- ☒ the drawings, sheets/figs None
- ☒ the sequence listing (specify): None
- ☒ any table(s) related to the sequence listing (specify): None

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing (specify): _____
- ☐ any table(s) related to the sequence listing (specify): _____

* If item 4 applies, some or all of those sheets may be marked "superseded."

Form PCT/IPEA/409 (Box No. I) (January 2004)

BEST AVAILABLE COPY

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US04/21307

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Claims 1-74 YES
Claims None NO

Inventive Step (IS)

Claims 1-74 YES
Claims None NO

Industrial Applicability (IA)

Claims 1-74 YES
Claims NONE NO

2. Citations and Explanations (Rule 70.7)

Claims 1-74 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest applying a kernel transform as claimed.

Claims 1-74 meet the criteria set out in PCT Article 33(4), and thus meet industrial applicability because the subject matter claimed can be made or used in industry.

----- NEW CITATIONS -----